

# PATENT SPECIFICATION

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## (54) RECOVERY OF NORMALLY ILLEGIBLE RECORDED INFORMATION

(71) We, R.C.A. CORPORATION, (formerly Radio Corporation of America), a corporation under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for reading recorded information from a record track. It has especially useful application in the case of magnetically recorded information, but as will be indicated later it may be equally applicable with other forms of recording.

In high density magnetic recording on a magnetic medium such as a magnetic tape, card, disc, drum or the like, there are generally a number of closely-spaced narrow record tracks which are read along their length to retrieve the recorded information. If the magnetic medium becomes damaged after the information is recorded, for example by dirt particles or abrasion, portions of the recorded information may be obliterated to such an extent that on normal reading they fail to be properly retrieved. An example of such damage are scratches which extend at an angle to the track direction and which may obliterate or otherwise make illegible one or more binary digits (bits) recorded along a track. Sometimes, however, the damage will only partially obliterate the information, and it is an object of the invention to increase the chances of proper retrieval in such circumstances.

The basis of the present invention is that a length of track from which erroneous information

has been read is re-read in a laterally shifted position, so that at an error location at which the recorded information has been obliterated across only part of the width of the track, the correct information may be retrieved on the second reading. It will be apparent that while the invention is especially applicable to the reading of magnetic record tracks, it is applicable in general to any kind of record track susceptible to damage extending part-way across the width of the track.

According to the present invention, apparatus for reading information from such a record track and including a reading head which is capable of reading along an area of the track of width relatively narrower than the track width, further includes means operable in response to detection of an error in the read information for causing at least the error-containing section of the length of the track to be re-read along a second area laterally shifted in the track relatively to the first read area. Thus, for example, if, as is usual, the reading head initially reads along a central area of the track width, the re-reading may take place along an area closer to one edge of the track. If the re-reading fails to produce a correct information read-out, a third reading may be performed along a third area of track (for example an area closer to the opposite edge of the track) laterally shifted relatively to both of the areas previously read.

In the accompanying drawings, by way of example:

Figure 1 is a schematic illustration of two record tracks on a portion of a recording medium;

Figures 2 and 3 are schematic illustrations of the method employed in the present invention.

tion for recovering information that might normally have been illegible; and

Figure 4 is a block schematic diagram of a portion of a reading system embodying the invention. In this Figure 4, the connecting lines crossed by regularly-spaced inclined short lines represent multiple-wire digital data connections.

A portion of a magnetic record medium is shown schematically in Figure 1. Magnetic information is recorded on this medium along tracks of width A which are spaced from one another a distance C. Information may be read from the tracks by creating relative movement between the record medium and the read head in the track direction. As is well understood in this art, the width B of the area scanned by the read head is normally substantially smaller than the width A of the record track and occurs at the centre of the record track. In one particular system, the various dimensions are  $A = 0.022"$ ,  $B = 0.012"$ ,  $C = 0.003"$ .

For any one of a number of reasons, it sometimes occurs that the record medium becomes damaged after the information is recorded thereon. A typical form of such damage consists of a scratch, such as shown at 6, which extends at an angle to the track direction. Such a scratch may obliterate one or more of the bits of recorded information and, of course, this results in reading errors.

The technique according to the present invention for recovering at least some of the otherwise illegible information such as described above is illustrated in Figures 2 and 3. First, the read head is moved a distance D to one edge of the recorded track and then relative movement is created between the read head and the record medium in the track direction. If the scratch is positioned such as shown in Figure 2, it now extends only a relatively small distance into the area scanned by the read head and does not seriously affect much of the information recorded there. There is therefore a very good probability that the stored information now can be read.

If on the pass of the record medium relative to the read head shown in Figure 2 the stored information still cannot be read, the read head is moved a distance 2D in the opposite direction and the same procedure repeated. Now information which would otherwise be obliterated by a scratch such as 7 in Figure 3 readily can be recovered. It has been found in one particular system that the technique of Figures 2 and 3 makes it possible to recover more than 90 per cent of the read errors which occur, i.e. of the otherwise illegible recorded information.

A system in which the technique described above is particularly useful is a magnetic card, mass memory system such as the RCA 3488 memory system or the RCA Spectra 70/568 memory system shown in part in Figure 4.

In these systems, information is stored on plastic cards approximately  $16"$  by  $4 \frac{1}{2}"$  which are coated with magnetic material. These cards are stored in magazines (not shown) and any card in any magazine may be randomly selected. One such selection scheme is described in British Patent No. 1,034,374. A card selected from a magazine passes into a track or raceway and is propelled by belts and rollers to the read/write station which is shown schematically in Figure 4. Element 10 in Figure 4 schematically represents the portion of the raceway immediately adjacent to the capstan 14. The card passes from the raceway portion 10 to the back surface of the generally triangularly shaped piece 12 and on to the capstan 14.

The capstan is continuously driven in the clockwise direction by capstan motor 16. A group of eight read heads and eight write heads are within the single structure 18 located adjacent to the capstan. They are capable of writing on and reading from eight interlaced tracks on the card 20.

The heads 18 are normally movable to any one of sixteen different positions by the positioner 21. The latter may be of the hydraulically actuated type as, for example, is employed in the commercially available equipment referred to above or of the electro-mechanical type as shown in U.S. Patent No. 3,266,329 or in British Patent No. 1,034,373. To move to one of sixteen different positions, the positioner can comprise four stages co-operating on a binary basis, each being capable of moving the group of heads through a different distance, as discussed, for example, in the foregoing U.S. Patent.

For the purposes of the present invention, the positioner has two additional stages, one capable of moving the heads a distance D equal, in one practical form of the invention, to approximately 5 mils (0.005 inches) and the other capable of moving the heads a distance equal to approximately 2D or 10 mils. The reason for these additional stages is to move the heads to the positions such that the read heads follow the areas of width B shown in Figures 2 and 3.

In the operation of the system of Figure 4, an instruction stored in the memory (not shown) of a data processing machine (not shown) may call for the selection of a particular card and for reading information from a group of tracks thereon. Upon receipt of such an instruction, the control unit 22, at an appropriate time, causes the card called for to be selected from a magazine and to be propelled to the capstan 14. Concurrently, the control unit applies a position command, consisting of a binary word, to the binary positioner 21 and the latter moves the heads 18 to a position such that they access the tracks called for by the instruction.

When the leading edge of the tracks on card 20 reaches the read heads, they begin reading

the information on a group of 8 tracks. The parity checker 23 checks this information for correct parity and applies it to the main memory (not shown) of the data processing machine (not shown) associated with the mass memory.

After a card has been read, the instruction may call for it to be returned to the magazine from which it was extracted. In such case, the gate controller 24 moves the gate 26 to a position such that the card moves over the near edge of the triangularly shaped piece 12 to the exit passageway 27. Alternatively, the instruction may call for the card again to be circulated on the capstan and the information read from another group of tracks on the card. In this case, the gate controller 24 maintains the gate 26 in position such that the card passes between the generally triangularly shaped piece 12 and the capstan. At the same time, a new position command is fed to the binary positioner 21 to move the heads to a new position corresponding to that of the new tracks it is desired to read.

In accordance with the present invention, when parity checker 23 indicates an error in the information being read from one or more of the eight tracks concurrently being read, it applies an error signal to the control unit. The latter, in response to this signal, applies a new position command to the binary positioner to cause it to move the heads a distance D in one direction. As mentioned above, this distance is one such as shown in Figure 2 which causes the read heads to scan an edge portion of all eight tracks one or more of which contain an error or errors. At the same time, the gate controller 24 maintains the gate 26 in a position such that the card remains on the capstan for at least a second pass. If during this second pass the error or errors previously found are corrected, then the next step in the instruction such as to return the cards to the magazine may be followed, just as in the case already discussed. On the other hand, if a parity error is still present, control unit 22 applies another position command to the binary positioner to cause it to move the heads 18 a distance 2D in the opposite direction. This causes the read heads to follow the path illustrated in Figure 3. At the same time, the controller 24 positions the gate 26 so that the card 20 remains on the capstan for a third pass.

Employing the technique described above, there is a very high probability that the so-called "drop out" errors, that is, the bits obliterated by damage to the recording medium, will be recovered. However, if after this procedure the error is still not recovered, the parity checker 23 so indicates to the control unit 22 and the latter actuates an alarm circuit (not shown) to indicate that there is a non-recoverable, drop out error.

While for purpose of ease of illustration, the system of Figure 4 is shown to employ the

gate structure 26, it may instead employ the new and improved card guiding structure described in U.S. Patent No. 3,329,424. This patent also shows some of the details of the means for keeping the card on the capstan during the rotation thereof. It is also to be understood that while the data recovery technique of the present invention is discussed in terms of a magnetic card system, it is applicable to magnetic tape and to other types of magnetic memory systems.

In the particular system described when an error is detected, the transverse movement between the tracks and read heads is accomplished by moving the reads until they are positioned close to one edge of the track. In other systems, it may be more practical to maintain the head or heads stationary and to move the record medium transversely thereto instead, in order to produce the lateral read area shifts required in accordance with the invention.

#### WHAT WE CLAIM IS:—

1. Apparatus for reading recorded information from a record track of a kind susceptible to information damage extending part-way across the track, said apparatus including a reading head capable of reading along an area of the track of width relatively narrower than the track width, and further including means operable in response to detection of an error in the read information for causing at least the error-containing section of the length of the track to be re-read along a second area laterally shifted in the track relatively to the first-read area.

2. Apparatus as claimed in Claim 1 wherein with the reading head arranged to read initially along a central area on the track, the re-read is caused to take place along an area nearer to one edge of the track.

3. Apparatus as claimed in Claim 1 including means operable in response to detection of an error in the re-read information for causing a further re-read along a third area laterally shifted relatively to both the first read area and the second read area.

4. Apparatus as claimed in Claim 3 wherein with the reading head arranged to read initially along a central area of the track, the first re-read and second re-read are caused to take place along areas respectively closer to one edge and the other of the track.

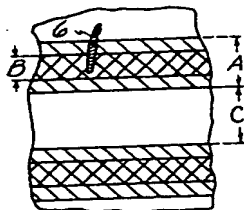
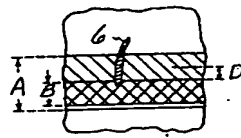
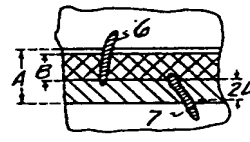
5. Apparatus as claimed in any preceding claim including an error detection arrangement and a position control arrangement able to cause change of the location of the reading head relatively to the track in a lateral direction, wherein in response to detection of an error the position control arrangement is caused to change the relative lateral location of the reading head according to the lateral area shift required for a re-read.

6. Recorded information reading apparatus of the kind in which reading means reads information recorded along a track on a record

- medium during relative movement of the reading means and the record medium and in which error in the read information may be corrected by variation of the position of the reading means transversely of the track, the apparatus including positioning means capable of variably positioning the reading means transversely of the track, and checking means capable of checking the read information for any transverse position of the detecting means, and of producing a signal indicating error in the information, the positioning means being operable in consequence of such a signal to shift the reading means.
- 15 7. Apparatus according to Claim 6 wherein the receipt of a succession of such error indicating signals is effective to cause the positioning means to shift the reading means through a predetermined sequence of positions.
8. Apparatus according to any preceding claim for reading magnetically recorded information from a magnetizable record medium.
9. Recorded information reading apparatus arranged for laterally shifted re-reading substantially as herein-before described with reference to Figures 1 and 2 or Figures 1, 2 and 3 of the accompanying drawings.
10. Recorded information reading apparatus substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.
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**Fig. 1.****Fig. 2.****Fig. 3.**